

**Lower San Juan Basin Groundwater Yield Enhancement Study
Work Plan**

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PROJECT OBJECTIVE, TASKS, AND SERVICES TO BE PERFORMED

The overall objective for this study is to evaluate feasible means to increase brackish/saline groundwater recovery and supply from the Lower San Juan Basin. This work will build off substantial work and progress made in the lower San Juan Basin over the past several years.

Description of Work

This project is a feasibility study that will investigate economic means for augmenting basin yield by increased recovery of brackish/saline groundwater from the Lower San Juan Basin by expanded extraction/recovery, by artificial recharge of streamflow through instream measures to increase yield, and by reduction of water losses to increase yield by eradication of non-native phreatophytes (e.g., *Arundo donax*).

The Groundwater Management Plan for the Lower Basin is currently under development by the San Juan Basin Authority who is participating and supporting this grant application. As part of development work for the SOCOD Project, which just completed an 18-month extended pumping and pilot plant test on the Test Slant Well, the groundwater model was developed both for the groundwater basin management planning effort and for SOCOD Project impact evaluation. The groundwater model will be utilized in this study to quantify benefits of identified basin improvement projects.

The study will look at means to enhance the economic capture of stormwater through spreading/streambed infiltration measures. This can help to increase the capture of stormflows during recession flow and improve water quality of the lower basin.

The basin has a network of groundwater monitoring wells from the shoreline to the upper reaches which are maintained either by SJBA, SCWD or MWDOC. SJBA manages the overall data set. This data base has been used in the groundwater model calibration. The monitoring well network will be used in ongoing groundwater basin monitoring and management operations. A review of the monitoring well network will be made to determine if additional monitoring wells are needed where data is insufficient for basin management purposes.

The expected outcome from this grant application work will be a surface water/groundwater yield analysis for the recommended enhancement measures. This

will account for extraction of 32,000 afy (1,600 afy brackish and 30,400 afy ocean water) from the ocean desalination project wellfield (16,000 afy of potable product water), modified upstream extraction well plan to allow an increase in basin production during dry periods, and conservation of a yet to be determined amount of water losses to the ocean. Measures include conservation of stormflow by instream spreading, increased groundwater recovery capacity, recovery of desalter brines, and a plan to maintain the eradication of invasive phreatophytes as well as estimating the impact of these non-native species on water supply and riparian habitat. Total increased stormwater conservation is estimated at 3,000 afy and brine recovery will add an additional 1,000 afy of potable supply. The total new yield with the slant beach wells and desalination at 16,000 afy plus the aforementioned yield components is expected to total about 20,000 afy.

Project Work Plan

Project Management. Mr. Richard Bell, Principal Engineer (MWDOC), will be the project manager responsible for the overall organization and control of project work, which will include:

1. Taking lead on all required coordination with project participants, regulatory agencies and NGOs;
2. Technical work direction and oversight;
3. Coordinating the Technical Advisory Committee review meetings and;
4. Supervising the day-to-day project activities to ensure adequate progress.

This project management task will include time spent in providing direction to the task leaders at the beginning of the tasks, providing ongoing technical oversight, and keeping track of work to ensure that the tasks are completed in a timely manner and within budget and on-schedule. This activity will also ensure coordination between the different task leaders. This task will include producing progress reports, financial reports, invoice submittals, tracking performance, and

costs and budget status reports. Mr. Bell will be responsible for all grant administration work.

Task 1 Increased Brackish/Saline Groundwater Recovery

This task will evaluate the potential for increased groundwater recovery based on existing water rights, agency plans, groundwater model yield studies, and plans for the SOCOD Project and its ability to salvage groundwater outflows to the ocean. This analysis will be based on the recently developed surface/groundwater model for Lower San Juan Basin. It will follow from the SJBA Conjunctive Use Study recommendations (January 2006).

Deliverable: Technical Memorandum

Task 2 Feasibility for Increased Conservation of Stormwater

This task will evaluate institutional/legal/regulatory approvals that would be required to conduct artificial spreading operations along Trabuco and Lower San Juan Creek and feasible methods to increase capture and infiltration of stormwater. The streambed is owned by the County of Orange.

Task 2.1 Streambed Spreading – Institutional and Regulatory Arrangements.

This task will involve meeting with Orange County Flood Control District who owns the stream channel and with San Juan Basin Authority to develop an interagency agreement to allow usage and operations in the streambed for enhancing streambed infiltration, spreading and conservation of stormwater, including meetings with the California Department of Fish and Game, National Marine Fishery Services and Regional Water Quality Control Board staffs on regulatory requirements for spreading operations.

Task 2.2 Streambed Spreading Operations. This task will evaluate streambed operation techniques that can be used to increase the infiltration of stormwater. Methods to be evaluated include use of sand dikes arranged in "T" patterns across the channel in order to both lengthen the flow path and flatten its gradient in order to increase infiltration. As part of this work, a review of infiltration decay rates due to particulate/microbial clogging will be obtained from Orange County Water District, which are considered relevant for this area. In addition, cleaning methods and cleaning frequency to maintain infiltration rates will be examined.

Task 2.3 Identify Potential Offsite Spreading Basins. This task will investigate areas along the tributaries of Trabuco and San Juan Creeks that might offer suitable locations for spreading basins. This work will build off the earlier SJBA conjunctive use study investigation. Identified sites will be evaluated for potential ability to recharge the stream basin, stream diversion methods, basin size, and potential yield. A field review will be conducted for each site. The sites will be mapped on suitable aerial photographs. Shallow hand cores will be taken to get a general indication of the soil conditions at each site and infiltration ring soil tests will be used to estimate infiltration rates. Existing data will also be reviewed. Candidate sites will then be determined and a borehole and field permeability test plan for each site will be scoped with a cost estimate to conduct a subsequent detailed site investigation (beyond the scope of this grant). SJBA previously conducted a conceptual analysis for use of the Galvan Flood Detention Basin on Arroyo Trabuco, but found the costs excessive. This task would examine if other areas may be available for off-site spreading basin development.

Task 2.4 Evaluate Streambed Infiltration Rates in Areas of Potential Artificial Spreading Operations. This task will evaluate the range of potential infiltration rates that occur both naturally and what might be able to be obtained through managed operations. Under natural conditions, depending on the magnitude of flow, a range of conditions can occur along the streambed: scouring out fine materials and cleaning of the stream sands/gravels, streambed cutting, bed load sediment

transport/deposition, preferential flow stream deposition of fine materials and clogging of the streambed, etc. Over the precipitation season, significant changes would be expected to occur and infiltration rates would be expected to be quite variable. In addition, subsurface sediments will also control the percolation rate.

This task will review published data for infiltration rates for similar types of streambed material found along Arroyo Trabuco and lower San Juan Creek and evaluate their applicability to a range of potential achievable rates. In addition, as part of the PACE flood control model work (County of Orange Flood Control, "*San Juan Creek Watershed Hydrology Study*", PACE, 2008), streambed samples were collected and sieve analyses were made. Rough approximations of vertical conductivity were made based on the gradation analyses. These will be summarized and compared to other locations. Preliminary results indicated that the Kv values derived from the sieve gradation analyses were quite high ranging from 2 feet/day to 412 feet/day.

This task will also review infiltration rates developed from the surface/groundwater flow model calibration. In addition, infiltration rates from selected artificial spreading sites in the region will also be reviewed. Based on the probable infiltration rates, an evaluation will be made to estimate initial spreading and decay rates for the candidate sites and then an evaluation will be made to estimate the annual enhanced yield by managed operations. Candidate sites include in-stream areas and possibly off-channel locations.

The 2006 SJBA Conjunctive Use Study investigated both stream reaches for potential spreading sites and performed a ranking of each site. From this work, site 5 was considered the best opportunity for spreading. Site 5 is situated just upstream of the La Novia Bridge on San Juan Creek. We will also review sites on Arroyo Trabuco to determine if a feasible spreading area can be found along this area. This task will utilize the groundwater model to estimate the enhanced yield under dry, average and wet conditions and then over a simulated long-hydrology period based on the

1947-2010 hydrology for both candidate in-stream and off-channel spreading basins.

Deliverable: Technical Memorandum

Task 3 Evaluate Radial/Collector Wells to Enhance Groundwater Yield and Groundwater Storage Utilization in Dry Years

This task would evaluate economic means to better utilize groundwater storage during dry periods by replacement of existing shallow vertical wells with radial collector wells. The San Juan Basin alluvial channel is relatively shallow, ranging from about 90 to 180 feet in thickness in the Lower San Juan Basin. All existing extraction wells in the Lower San Juan Basin are vertical wells with 50 foot blank sanitary seals. In some areas, groundwater pumping levels can drop below the blank casing into the screened zone, allowing cascading aerated water to enter the well, bringing oxic water down into the well.

Since the groundwater in this area is enriched with dissolved iron and manganese. The addition of air into the well promotes oxidation of the dissolved iron which in turn promotes accelerated biofouling growth that then clogs the well screen. This has been a serious problem for the San Juan Capistrano Groundwater Recovery Plant which had to install Variable Frequency Drives (VFD's) on their wellheads in order to maintain pumping levels above the screened zones. SCWD also operates their well in a similar manner.

As a consequence, water well operations are now restricted to maintaining pumping water levels above the screened interval for the two groundwater desalter projects. In the future, under dry periods groundwater yields would decrease with falling groundwater levels. This would also reduce the capability of the existing vertical wells to adequately perform during dry periods and would accelerate biofouling and loss of capacity.

An alternative method to pump water from relatively shallow stream systems is the use of radial/collector wells, a technology that was invented for shallow alluvial streams in the 1930's. In California, these types of wells have long been used along the American River and Russian River. This task would evaluate the feasibility and yield from these types of wells to allow for increased groundwater production at the two existing groundwater recovery plants, especially during dry periods.

Task 4 Arundo Removal Programs and Assessment of Water Yield

Arundo donax (Giant Reed) is a non-native species that has become a major infestation throughout southern California, including in the San Juan Creek stream system, as it has spread over a large area. A recent study by the California Invasive Plant Council found that in the San Juan Basin, the extent of *Arundo* was 173 acres in 2010/11.

Arundo is a very fast growing plant and is considered to be one of the largest water consuming plants in the world. A review of the literature indicates that *Arundo donax* can consume substantially more water than consumed by native riparian habitat. Dense stands in wet and warm areas are reported to consume up to 24 feet of water per acre per year. In addition to its streamflow depletion impact, it concentrates salts, destroys native habitat, and is a highly flammable species.

The CIPC found that the consumptive use potential for the 173 acres of *Arundo* in the San Juan Creek and tributaries is over 4,150 afy. Removal of *Arundo* and replacement with native riparian habitat would provide a net water supply savings of about 3,500 afy, a significant amount of water that is now being annually lost due to this invasive plant, as well as significant habitat improvement.

Because of the destructive nature of this non-native phreatophyte, efforts by volunteer groups, local agencies, Orange County and the Federal Government have

been employed over the years in an attempt to eradicate non-native and other non-native plants from the watershed, but no organized, well funded, on-going program currently exists.

This task will provide an overview of the prior Arundo removal programs in the watershed, their status, and the estimated water yield savings that has been derived from the Arundo eradication program. This work will also review the CIPC study and other data to estimate the potential water savings to Lower San Juan Basin that could be gained from complete eradication and replacement by native habitat. Long-term plans to maintain Arundo monitoring and control for long-term water supply and habitat benefits to the San Juan Basin will be discussed with the County, CIPC, OCWD (they are actively involved in similar efforts on the Santa Ana River), and USFS. The County and US Army Corps of Engineers *"San Juan Creek Watershed Management Plan"*, September 2002 also identified this as a major issue.

The 2002 Plan called for an initial eradication effort in an "upstream-to-downstream" approach and that a "pool" of funding be established, involving the US Army Corps of Engineers Regulatory Branch, State of California Department of Fish and Game, and other resource agencies to address this existing and ongoing need. This task will follow up on the outcome of that recommendation and what might be feasible as a continuing program.

Since water supply is a major potential benefit of maintaining control of invasive phreatophytes, the cost and benefits for water supply from these programs will be evaluated and a recommendation then fashioned. The CIPC report estimates the benefit-cost ratio is greater than 2-1. We think it is higher and will provide an evaluation in this work.

Deliverable: Technical Memorandum

Task 5 Effectiveness of Slant Wells to Salvage Groundwater Outflow Losses to the Ocean and to Control Seawater Intrusion

This task will utilize the focused coastal groundwater flow and variable density groundwater model to evaluate the effectiveness of the planned SOCOD Project slant intake well field along the mouth of San Juan Creek to salvage groundwater outflow losses. In the lower reach of San Juan Creek, outflow losses to the ocean can be from subsurface outflow, rising groundwater outflow, and stormwater discharges

Along the lower reaches of San Juan Creek and extending out under the ocean, there are three distinct aquifers. A shallow aquifer that is in direct continuity to the stream and ocean is underlain by a 4-foot clay layer at minus 13 feet (NAVD88). The middle aquifer occurs from about 40 feet bgs to 140 feet bgs. A deeper, interbedded basal aquifer zone occurs from about 140 feet to over 188 feet bgs.

The slant beach wells are planned to be tapped into the middle aquifer and possibly through the deeper aquifer to provide for full penetration of the aquifer. The calibrated model can be used to estimate the water losses to the ocean without the project under various upstream extraction and spreading operational scenarios and then can be used to evaluate the SOCOD Project to determine both the effect of the SOCOD Project on groundwater levels and its capture of losses to the ocean.

Reduction of streamflow and groundwater losses to the ocean by inland pumping will increase basin yield but will cause seawater intrusion in dry years or under periods of lower storage levels. The SOCOD Project slant wellfield extraction trough will also control seawater intrusion. This task will evaluate the salvage of outflow

losses to the ocean and the control of seawater intrusion over an extended test period.

Deliverable: Technical Memorandum

Task 6 Recovery of Desalter Brines by the SOCOD Project

This task will evaluate the feasibility for recovery of brackish groundwater recovery plants reverse osmosis brines by the planned South Orange Coastal Ocean Desalination Project. Recovery of brines effectively increases basin yield. The City of San Juan Capistrano and South Coast Water District groundwater desalters produce in total about 1.05 mgd of brine. This brine has a concentration of about 10,000 mg/l. At the San Juan Capistrano Groundwater Recovery Plant, all groundwater is first treated to remove iron and manganese, and as a consequence the brine is free of iron and manganese. Based on initial evaluation of the brine chemistry, it appears suitable for a feedwater to the SOCOD Project which would be desalting mostly seawater up to 33,500 mg/l in salinity. This option, if feasible, would reduce disposal costs to the City and reduce the ocean desalination cost by slightly reducing the plant weighted average feedwater salinity.

This task would evaluate the feasibility of using the desalter brines (concentrate streams) in the feedwater to the SOCOD Project. Recognizing the brackish concentrate stream has a lower TDS concentration than seawater, blending a minor contribution of the concentrate with raw seawater will lower the seawater RO feedwater concentration. Potential benefits include lower operating pressure, lower permeate concentration, and eliminating brackish concentrate disposal and costs.

Challenges include understanding potential interaction of differing constituents and properties of each stream that might cause scaling or accelerated fouling. An assessment of the water chemistry of each stream and the resulting combined feedwater will be performed, relative to its suitability as an RO feedwater and potential pretreatment implications. An order-of-magnitude level cost estimate will

be prepared to quantify the potential capital cost of implementation as well as operational cost savings/expenses which would result.

Deliverable: Technical Memorandum

Task 7 Review of Southern Steelhead Recovery and Habitat Restoration Plans

This task will review the NMFS southern Steelhead recovery program and its status, when steelhead would be expected to spawn or run to the ocean, flow conditions that would be favorable for steelhead, and how this program may affect the conservation and spreading of stormwater. Trout Unlimited has been working on the design of fish ladders on Arroyo Trabuco at the Metrolink railroad crossing which poses a barrier to upstream spawning. To date, only construction funds have been made available to Trout Unlimited and no maintenance funding is available. Consequently, the County of Orange has not approve these facilities and is requiring Trout Unlimited to own and maintain them. The County has no funds for their installation or upkeep.

These efforts will be discussed with NMFS, CDFG, Regional Water Quality Control Board, Trout Unlimited (TU) and the County to gain a better understanding of the intent of this program and its relationship and effect on enhancing the development of the groundwater supply of Lower San Juan Creek.

Deliverable: Technical Memorandum

Task 8 Project Management, Meetings, Public Participation, Presentations, and Report Preparation

This task covers project management, public participation, preparation of presentations and meeting attendance, and preparation of the draft and final project report by the project consultant. The draft and final report will summarize findings, conclusions and recommendations from Tasks 1 – 8. Our Public Affairs department

will be handling the dissemination of information to the public and our stakeholders. Under routine progress reporting to our Board committee structure, the status of the work products and reports will be placed in agendas that are available to the public on our website. These efforts will be coordinated with the San Juan Basin Authority and SOCOD Project Participants Committee.

Deliverables: Quarterly Progress Reports, Newsletter and Invoices
Draft and Final Report